REMARKS

In the Specification

Please replace the paragraph on page 1, starting from line 10 with the following clean copy text:

A1

As the process of fabricating a semiconductor device enter into the submicron territory, copper has replaced aluminum for the wiring processes. Compared with aluminum, copper has a resistivity 30% lower and an electromigration resistivity 30 times or 100 times higher than aluminum. A via contact is thus formed with a resistance 10 to 20 times lower.

Please replace the paragraph on page 2, starting from line 15 with the following clean copy text:

A2

The present invention is to provide a method of fabricating a damascene structure that prevents carbon-rich particles from adhering onto a surface of a metal layer.

Please replace the paragraph on page 3, starting from line 6 with the following clean copy text:

A3

The characteristic of the present invention is to use the second slurry with an oxidant during the chemical mechanical polishing process for removing the barrier layer, in which the zeta potential of the metal layer is changed when the oxidant reacts with the metal layer. Therefore, carbon-rich particles will not adhere onto the surface of the metal layer and no scratching occurs on the metal surface. As a result, defects of the wafer can be reduced, and the reliability and performance of the device can be improved.

Please replace the paragraph on page 5, starting from line 4 with the following clean copy text:

Referring to Fig 1C, a chemical mechanical polishing process is performed to remove the metal layer 108 with a first slurry 110. The metal layer 108 is polished away until the barrier layer 106 is exposed. The barrier layer 106 acts as a polishing stop layer to remove a portion of the metal layer 108. The slurry 110, for example, can be a metal-polishing slurry that comprises water, abrasive particles, surfactant, buffer solution, and an anti-corrosive agent etc. The surfactant is used for separating the abrasive particles to prevent the abrasive particles clotted or aggregated. The buffer solution is used to control the pH values of the slurry 110. The anti-corrosive agent is used to prevent the slurry 110 from corroding the metal layer 108.

A4

Please replace the paragraph on page 6, starting from line 5 with the following clean copy text:

The slurry 112, for example, can be slurry for the barrier layer, which comprises water, abrasive particles, surfactant, buffer solution, and an anti-corrosive agent etc. The surfactant is used for separating abrasive particles to prevent the abrasive particles clotted or aggregated. The buffer solution is used to control the pH values of the slurry 112. The pH of slurry 112 should be neutral or alkaline. The anti-corrosive agent is used to prevent the slurry 112 from corroding the metal layer 108.

A5

Please replace the paragraph on page 6, starting from line 19 with the following clean copy text:

According one preferred embodiment of the present invention, the slurry added with the oxidant is used for the chemical mechanical polishing process for the barrier layer. An experiment is carried out to determine the total defects of the wafer. The total defect count of the wafer that is polished by the slurry without adding oxidant is higher than the total defect count of the wafer that is polished by the slurry with oxidant added. According to the experiment, the total defect count of the wafer that is polished by the slurry without adding oxidant is about 1101, and the total defect count of the wafer that is polished by the slurry with oxidant added is about 22. Therefore, from the result of the experiment, adding oxidant in the slurry can tremendously reduce the total defect count of the wafer.

In the Claims

Please substitute the following clean copy text for the pending claims of the same number:

1. (Once Amended) A method of fabricating a damascene structure, comprising:

providing a substrate;

forming a dielectric layer on the substrate;

defining the dielectric layer to form an opening, wherein a portion of the substrate is exposed by the opening;

forming a barrier layer conformal to a profile of the opening;

forming a metal layer over the substrate, wherein the metal layer fills the opening and covers the dielectric layer;

performing a first chemical mechanical polishing process with a first slurry to remove the metal layer until the barrier layer is exposed; and

performing a second chemical mechanical polishing process with a second slurry and a solution to remove the barrier layer and adjusting a zeta potential of the metal layer with the solution during the removal of the barrier layer.

3. (Once Amended) The method of claim 1, wherein the oxidant is selected form the group consisting of KIO_3, H_2O_2, $Fe(NO_3)_3$ and $(NH_4)_2S_2O_8$.

5. (Once Amended) The method of claim 2, wherein the oxidant is either dissolved into the solution and then mixed with the second slurry from different pipelines on a polishing pad or is added directly to the second slurry.

6. (Once Amended) The method of claim1, wherein the dielectric layer is made of a low-K material and is selected from the group of fluorinated organic polymers consisting of fluorinated hydrocarbon, fluorinated poly arylene ether aromatic polymer and hydrogen silsesquioxane.

7. (Once Amended) The method of claim 1, wherein a material of the metal layer is selected from the group consisting of copper, tungsten and aluminum.

8. (Once Amended) The method of claim 1, wherein a pH of the second slurry can be neutral.

9. (Once Amended) The method of claim 1, wherein a pH of the second slurry can be alkaline.

10. (Once Amended) The method of claim 1, where the opening is a dual damascene opening, a trench for a metal conductive line, a via opening for a plug, a contact opening or an opening for a damascene structure.

11. (Once Amended) A method of fabricating a damascene structure, comprising:

providing a substrate, wherein the substrate comprises a dielectric layer with an opening on the substrate, a barrier layer conformal to a profile of the opening and a metal layer filling up the opening;

performing a first chemical mechanical polishing process with a first slurry to remove the metal layer; and

performing a second chemical mechanical polishing process with a second slurry that comprises an oxidant to remove a portion of the barrier layer and to adjust a zeta potental of the metal layer.

12. (Once amended) The method of claim 11, wherein the oxidant is either dissolved into a solution and the mixed with the second slurry from different pipelines on a polishing pad or is added directly to the second slurry.

13. (Once Amended) The method of claim 11, wherein the oxidant is selected form the group consisting of KIO_3, H_2O_2, $Fe(NO_3)_3$ and $(NH_4)_2S_2O_8$.

15. (Once Amended) The method of claim 11, wherein a pH of the second slurry can be neutral.

16. (Once Amended) The method of claim 11, wherein a pH of the second slurry can be alkaline.

17. (Once Amended) The method of claim 11, wherein a material of the metal layer is selected from the group consisting of copper, tungsten and aluminum.

Please cancel claims 18-20 without prejudice or disclaimer.

Please add the following new claims:

21. (Newly added) The method of claim 1, wherein the second slurry for removing the barrier layer comprises an oxidant, abrasive particles, surfactant, buffer solution, and anti-corrosive.

22. (Newly added) The method of claim 11, wherein the second slurry for removing the barrier layer comprises an oxidant, abrasive particles, surfactant, buffer solution and anti-corrosive.

Present Status of the Application

This Amendment is promptly filed to place the above-captioned case in condition for allowance. Claims 1, 3, 5-13 and 15-17 have been amended to more accurately describe the invention. An annotated version of claims 1, 3, 5-13 and 15-17 illustrating the changes made thereto, is attached hereto as Exhibit A. The language in the amendment of claims 1, 3, 5-13 and 15-17 are added for clarification and proper interpretation of the claims we set forth in our specification and are well support by the specification. Claims 18-20 have been canceled without prejudice or disclaimer. Dependent claims 21-22 have been added. No new matter has been added to the application by the amendments made to the claims or otherwise in the application. For at least the following reasons, it is submitted that this application is in condition for allowance. Reconsideration and withdrawal of the Examiner's rejection is respectfully requested.

Summary of Applicant's Invention

The Applicant's invention is directed to a method for fabricating a damascene structure. More noticeably, a first chemical mechanical polishing process is performed with a first slurry to remove the metal layer until the barrier layer is exposed. A second chemical mechanical polishing process is further performed with a second slurry and a solution to remove the barrier layer and to adjust the zeta potential of the metal layer during the removal of the barrier layer.

Advantageously, the zeta potential of the metal layer is approximate to that of the carbon-rich particles to prevent the particles from adhering onto the surface of the metal layer and to minimize defects formed on the surface of the metal layer.

Response to Restriction Requirement

Restriction to one of the following invention is required under 35 U.S.C. 121:

I. Claims 1-17 which are drawn to a method of fabrication a damascene structure

II. Claims 18-20, which are drawn to a polishing slurry

Applicants choose to elect Group I, Claims 1-17 for examination and cancel claims 18-20 without prejudice or disclaimer. Applicants, however, reserve the right to pursue the subject matter of these canceled claims in a continuing application if Applicants so choose.

Response to Objections

The various informalities due to grammatical and idiomatic errors in the specification and in the claims have been corrected. Withdrawal of the objections is respectively requested.

Response to 35 U.S.C. 103 (a) rejection

Claims 1-17 are rejected under 35 U.S.C. 103(a) as being unpatentable Farkas et al. (U.S. 6,001,730, Farkas hereinafter).

Applicants respectfully traverse the rejection under 35 U.S.C. 103(a) for at least the reason that Farkas fails to disclose or suggest every claimed feature of the present invention. More specifically, the present invention teaches "*performing a second chemical mechanical polishing process with a second slurry and a solution to remove the barrier layer and adjusting a zeta potential of the metal layer with the solution during the removal of the barrier layer.*" It is essential for the instant case that during the removal of the barrier layer, the second slurry that is used to remove the barrier layer includes a solution that also alters the zeta potential of the metal

layer. The solution that is included in the second slurry comprises, for example, an oxidant. As a result, the carbon-rich particles, generated from the low K dielectric layer underneath the barrier layer, are prevented from adhering onto the surface of the metal layer while the barrier layer is removed. Farkas, on the contrary, teaches the first CMP process for removing the metal layer is conducted with a slurry that contains an oxidizing agent (col. 5, lines 43-60). **The second CMP process for removing the barrier layer of Farkas is conducted with a slurry that contains silica abrasive and an ethylendiamine additive instead** (col. 6, lines 31-56). The ethylendiamine additive in Farkas' slurry for the second CMP process is to provide a faster polish rate for the barrier layer 21 than the dielectric layer 20 or the metal interconnect 22. There is no where in Farkas that teaches or suggests **adjusting the zeta potential of the metal surface during the removal of the barrier layer** to protect the integrity of the metal layer.

For at least the reasons discussed above, Applicants respectfully submit that Farkas does not render the claims 1 and 11 obvious. With regard to dependent claims 2-10 and 12-20 Applicants respectfully submit that these claims patently define over the prior art for at least the same reasons as independent claims 1 and 10. Withdrawal of the rejection and allowance of the application are earnestly requested.

Newly Added Claims

Applicants have added dependent claims 21-22, which are dependent from claims 1 and 11, respectively, to further narrow the scoped as provided for within the disclosure. Therefore, it is submitted that claims 21-22 are in condition for allowance for the above reasons.

CONCLUSION

For at least the foregoing reasons, it is believed that all pending claims 1, 2-10 and 12-17, 21-22 are in proper condition for allowance. If the Examiner believes that a telephone conference would expedite the examination of the above-identified patent application, the Examiner is invited to call the undersigned. Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "**Version with markings to show changes made.**"

Dated: May 17, 2002

WU & CHEUNG, LLP

By: _____

Charles C.H. Wu, Esq.
REG. NO. 39,081
7700 IRVINE CENTER DRIVE, STE. 710
IRVINE, CALIF. 92618-3043
TEL: 949-251-0111
FAX: 949-251-1588
E-MAIL: CCHWU @ EARTHLINK.NET
USPTO CUSTOMER NO.: 25864

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification:

Please amend the paragraph on page 1, starting from line 10 as follow:

As the process of fabricating a semiconductor device enter into [a] the submicron [technology] territory, copper has replaced aluminum for the wiring processes. Compared with aluminum, copper has a resistivity 30% lower and an electromigration resistivity 30 times or 100 times [bigger] higher than aluminum[, thus forming a via contact with 10 to 20 times lower resistance]. A via contact is thus formed with a resistance 10 to 20 times lower.

Please amend the paragraph on page 2, starting from line 15 as follow:

The present invention is to provide a method of fabricating a damascene structure [to prevent] that prevents carbon-rich particles from adhering onto a surface of a metal layer.

Please amend the paragraph on page 3, starting from line 6 as follow:

The characteristic of the present invention is to use the second slurry with an oxidant [for the barrier layer] during the chemical mechanical polishing process for removing the barrier layer, in which [can change] the zeta potential of the metal layer is changed when the oxidant reacts with the metal layer. Therefore, carbon-rich particles will not adhere onto the surface of the metal layer and no scratching occurs on the metal surface. As a result, defects of the wafer can be reduced, and the reliability and performance of the device can be improved.

Please amend the paragraph on page 5, starting from line 4 as follow:

Referring to Fig 1C, a chemical mechanical polishing process is performed to remove the metal layer 108 with a first slurry 110. The metal layer 108 is polished away until the barrier layer 106 is exposed. The barrier layer 106 acts as a polishing stop layer to remove a portion of the metal layer 108. The slurry 110, for example, can be a metal-polishing slurry that comprises water, abrasive particles, surfactant, buffer solution, and an anti-corrosive agent etc. The surfactant is used for separating the abrasive particles to prevent the abrasive particles clotted or aggregated. The buffer solution is used to control the pH values of the slurry 110. The anti-corrosive agent is used to prevent the slurry 110 from corroding the metal layer 108.

Please amend the paragraph on page 6, starting from line 5 as follow:

The slurry 112, for example, can be slurry for the barrier layer, which comprises water, abrasive particles, surfactant, buffer solution, and an anti-corrosive agent etc. The surfactant is used for separating abrasive particles to prevent the abrasive particles clotted or aggregated. The buffer solution is used to control the pH values of the slurry 112. The pH of slurry 112 should be neutral or alkaline. The anti-corrosive agent is used to prevent the slurry 112 from corroding the metal layer 108.

Please amend the paragraph on page 6, starting from line 19 as follow:

According one preferred embodiment of the present invention, the slurry added with the oxidant [for the barrier layer] is used for the chemical mechanical polishing process for the barrier layer. An experiment is carried out to determine the total defects of the wafer. The total defect count of the wafer that is polished by the slurry without adding oxidant is higher than the total defect count of the wafer that is polished by the slurry with oxidant added. According to the

experiment, the total defect count of the wafer that is polished by the slurry without adding oxidant is about 1101, and the total defect count of the wafer that is polished by the slurry with oxidant added is about 22. Therefore, from the result of the experiment, adding oxidant in the slurry can tremendously reduce the total defect count of the wafer.

In the Claims:

Please cancel claims18-20 without prejudice or disclaimer.

Please add new claims 21-22.

Please amend the following claims:

1. (Once Amended) A method of fabricating a damascene structure, comprising:

providing a substrate;

forming a dielectric layer on the substrate;

defining the dielectric layer to form an opening, wherein a portion of the substrate is exposed by the opening;

forming a barrier layer conformal to a profile of the opening;

forming a metal layer over the substrate, wherein the metal layer fills the opening and covers the dielectric layer;

performing a first chemical mechanical polishing process with a first slurry to remove the metal layer until the barrier layer is exposed; and

performing a second chemical mechanical polishing process with a second slurry and a solution to remove the barrier layer[, wherein the solution can adjust the zeta potential of the metal layer] and adjusting a zeta potential of the metal layer with the solution during the removal of the barrier layer.

3. (Once Amended) The method of claim 1, wherein the oxidant is selected form [a] the group consisting of KIO_3, H_2O_2, $Fe(NO_3)_3$ and $(NH_4)_2S_2O_8$.

5. (Once Amended) The method of claim 2, wherein the oxidant is either dissolved into the solution and then mixed [up] with the second slurry from different pipelines on a polishing pad [from different pipelines] or is added directly to the second slurry.

6. (Once Amended) The method of claim1, wherein the dielectric layer is made of a low-K material and is selected from [a] the group of fluorinated organic polymers [group] consisting of fluorinated hydrocarbon, fluorinated poly arylene ether aromatic polymer and hydrogen silsesquioxane.

7. (Once Amended) The method of claim 1, wherein a material of the metal layer is selected from [a] the group consisting of copper, tungsten and aluminum.

8. (Once Amended) The method of claim 1, wherein [the] a pH of the second slurry can be neutral.

9. (Once Amended) The method of claim 1, wherein [the] a pH of the second slurry can be alkaline.

10. (Once Amended) The method of claim 1, where the opening [can be] is a dual damascene opening, a trench for a metal conductive line, a via opening for a plug, a contact opening or an opening for a damascene structure.

11. (Once Amended) A method of fabricating a damascene structure, comprising:

providing a substrate, wherein the substrate comprises a dielectric layer with an opening on the substrate, a barrier layer conformal to a profile of the opening and a metal layer filling up the opening;

performing a first chemical mechanical polishing process with a first slurry to remove the metal layer [until the dielectric layer is exposed]; and

performing a second chemical mechanical polishing process with a second slurry that comprises an oxidant to remove a portion of the barrier layer and to adjust a zeta potental of the metal layer [to form a damascene structure].

12. (Once amended) The method of claim 11, wherein the oxidant is either dissolved into a solution and then mixed[up] with the second slurry from different pipelines on a polishing pad [from different pipelines] or [adding] is added directly to the second slurry.

13. (Once Amended) The method of claim 11, wherein the oxidant is selected form [a] the group consisting of KIO_3, H_2O_2, $Fe(NO_3)_3$ and $(NH_4)_2S_2O_8$.

15. (Once Amended) The method of claim 11, wherein [the] a pH of the second slurry can be neutral.

16. (Once Amended) The method of claim 11, wherein [the] a pH of the second slurry can be alkaline.

17. (Once Amended) The method of claim 11, wherein a material of the metal layer is selected from [a] the group consisting of copper, tungsten and aluminum.